Popular Science
September 2009

INSTANT EXPERT

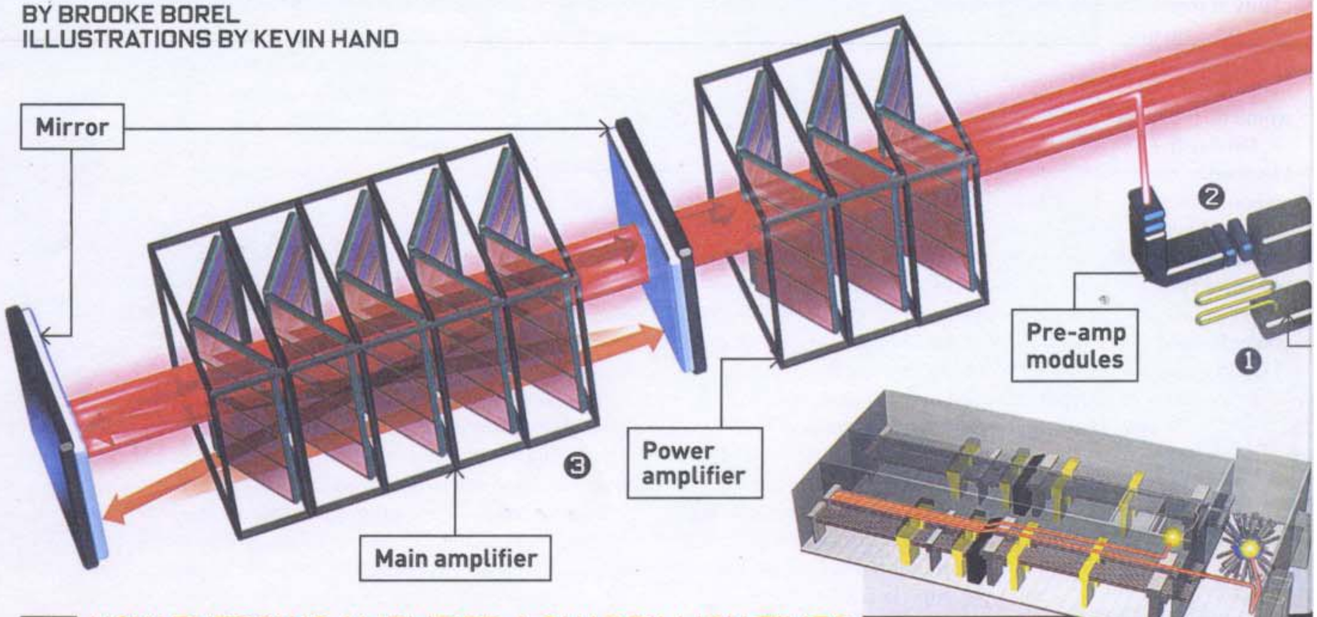
EVERYTHING YOU NEED TO KNOW, NOTHING YOU DON'T

THE WORLD'S BIGGEST LASER

NUCLEAR FUSION, ENDLESS ENERGY AND HOMEMADE STARS MIGHT BECOME POSSIBLE WITH THE DEPARTMENT OF ENERGY'S NEW MACHINE

The laser that will fire at targets this fall at the National Ignition Facility in Livermore, California, isn't just more energetic than other lasers; it produces beams with *60 times* as much energy. What to do with all that power? Ignite a nuclear-fusion reaction, of course. All two million joules from NIF's laser will converge on a BB-size fuel capsule filled with hydrogen isotopes. The reaction takes place in less than 20 billionths of a second, birthing a mini star inside the 33-foot-wide chamber. Once researchers figure out how to fire the laser a couple times a second (rather than a couple times a day), it may also pave the way for sustainable energy: More-efficient optical equipment could help NIF create the first laser-fusion reaction to produce more energy than it consumes.

BY BROOKE BOREL
ILLUSTRATIONS BY KEVIN HAND



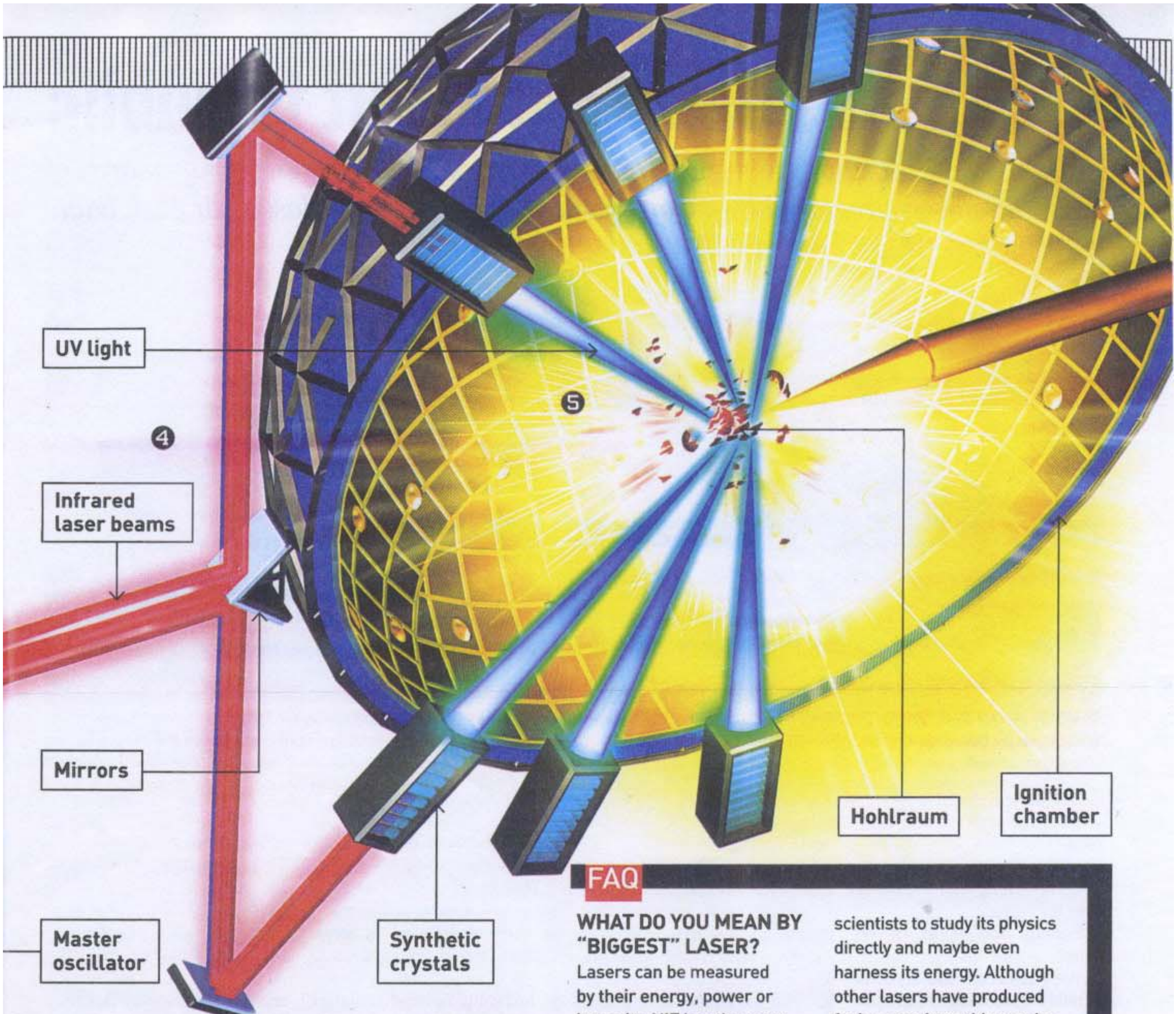
HOW ENERGY IS AMPLIFIED A QUADRILLION TIMES

1 The laser beam starts as low-energy infrared pulses in a small laser called the **master oscillator**. The pulses possess only a few nanojoules of energy, less than a trillionth of the amount of energy contained in a stick of sugarless gum.

2 Mirrors called beam splitters divide the beam into 48 parts; fiber-optic cables transport the beams to **pre-amp modules**, which amplify each beam up to 10 billion times, to a few joules. Before going into the **power amplifier**, the beams are split again, into 192 separate beams.

3 The laser runs through the **power** and **main amplifiers**, made of neodymium-doped glass. Light from high-powered lamps excites the neodymium atoms, which transfer that energy to the laser beams. The 192 beams now possess 21,000 joules each, totaling four million joules of infrared light.

4 Mirrors redirect the beams so that they will simultaneously converge on the **ignition chamber**. At its center is the target, called the **hohlraum**, a metal cylinder the size of a pencil eraser that holds a fuel capsule containing the hydrogen isotopes deuterium and tritium.



OVERVIEW OF THE FACILITY The building housing NIF is large enough to contain three football fields. From their start in the master oscillator to their endpoint in the ignition chamber, the laser beams travel some 4,000 feet.

5 As the beams enter the ignition chamber, they filter through **synthetic crystals**, which convert them from infrared to ultraviolet light, halving the energy to about two million joules. The UV beams hit the hohlraum, generating intense x-rays inside it. The x-rays create a uniform pressure nearly 100 million times that of the Earth's atmosphere and heat the isotopes to 100 million degrees. The extreme pressure and temperature fuse the nuclei of the deuterium and tritium together, and the fuel capsule implodes in a reaction that releases 10 to 20 times as much energy as the laser put in. In a few years, it could create as much as 40 million joules.

FAQ

WHAT DO YOU MEAN BY "BIGGEST" LASER?

Lasers can be measured by their energy, power or intensity. NIF has the most energy. The Texas Petawatt laser at the University of Texas currently boasts the highest power, at 1,000 trillion watts but lasting only 150 quadrillionths of a second. The Hercules laser at the University of Michigan is the most intense: 300 trillion watts, concentrated on an area just over one micron in diameter.

WHY DO WE NEED A LASER THIS BIG?

NIF will, in effect, create a star here on Earth, allowing scientists to study its physics directly and maybe even harness its energy. Although other lasers have produced fusion reactions, this may be the first laser to create *more* energy than it's using.

SO—FREE ENERGY, RIGHT?

Not yet. NIF can handle only a few ignitions a day because the optical components need time to cool down. According to NIF program leader Erik Storm, it could be two decades before fusion energy is available. One key will be to replace the capacitors with diode lasers. That would let NIF run cooler, allowing for 10 to 15 ignitions per second.